

California Environmental Protection Agency



**PERMEATION RATES OF
SMALL OFF ROAD ENGINE
HIGH - DENSITY POLYETHYLENE
FUEL TANKS
(FEBRUARY 2001 TESTING)**

Engineering and Certification Branch
Monitoring and Laboratory Division

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Introduction

The California Air Resources Board (CARB) staff tested twelve High-Density Polyethylene (HDPE) fuel tanks to determine their permeation rates. Tanks were preconditioned with commercial fuel, refilled with Phase II California Reformulated Certification (CERT) fuel, and subjected to a variable temperature profile. Permeation rates were then determined gravimetrically during the month of February.

Test Protocol

In January, the untreated tanks used with 4-cycle engines underwent the preconditioning process using commercial fuel, per CARB Test Method 513. Untreated tanks used with 2-cycle engines underwent the preconditioning process using a 2% commercial fuel/oil mixture. The tanks were stored at ambient temperature and pressure in flameproof storage cabinets. After four weeks of ambient preconditioning, the tanks were emptied; dried with compressed zero air, and immediately refilled with either CERT fuel or a 2% CERT fuel mixture. The tanks were then sealed using a hand held fusion welder and 1/4" thick HDPE coupons and leak tested as specified in Test Method 513 (a copy can be found at the CARB web site: <http://www.arb.ca.gov/regact/spillcon/spillcon.htm>).

Weight loss was used to determine relative permeation rates. Sealed tanks were weighed using a 16,000 gram or 6,200 gram balances with sensitivities of ± 0.1 and ± 0.01 grams respectively. After each tank was weighed, the weight was recorded. They were then placed in the Sealed Housing for Evaporative Determination (SHED) and exposed to a 1-day/24-hour/1440-minute variable temperature profile (see Attachment 1). This profile is considered our diurnal cycle (recurring every day). Tanks were then post weighed after each 24-hour diurnal cycle and the weight loss calculated.

Results

Cumulative weight losses were determined for each container as a function of time. The tanks underwent multiple diurnal cycles, but results are calculated using only the last five 24 hour cycles. The initial days of test data were not used in determining individual per container permeation rates due to high variability. A summary of all test results can be found in Attachment 2.

The average permeation rate from the 0.09 gallon 2-cycle chainsaw tank designated T1 was determined to be 1.31 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon eXmark tank designated T3 was determined to be 0.55 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 1.4 gallon Murray tank designated T4 was determined to be 1.27 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 1.7 gallon Snapper tank designated T5 was determined to be 0.67 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon Toro tank designated T7 was determined to be 0.77 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 5 gallon Tecumseh tank designated T11 was determined to be 0.64 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.08 gallon Echo tank designated T12 was determined to be 3.42 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.55 gallon Shindaiwa tank designated T13 was determined to be 2.26 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.38 gallon Stihl tank designated T14 was determined to be 0.72 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.74 gallon B&S tank designated T16 was determined to be 2.46 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.29 gallon Honda tank designated T17 was determined to be 4.57 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

The average permeation rate from the 0.12 gallon Honda tank designated T25 was determined to be 4.23 grams/gallon/day. This rate is based on data averaged from tests of five 24-hour diurnal cycles.

Attachment 1

1 Day / 24 Hour / 1440 Minute Variable Temperature Profile

HOUR	MINUTE	TIME REMAINING (MINUTES)	TEMPERATURE (°F)
0	0	1440	65.0
1	60	1380	66.6
2	120	1320	72.6
3	180	1260	80.3
4	240	1200	86.1
5	300	1140	90.6
6	360	1080	94.6
7	420	1020	98.1
8	480	960	101.2
9	540	900	103.4
10	600	840	104.9
11	660	780	105.0
12	720	720	104.2
13	780	660	101.1
14	840	600	95.3
15	900	540	88.8
16	960	480	84.4
17	1020	420	80.8
18	1080	360	77.8
19	1140	300	75.3
20	1200	240	72.0
21	1260	180	70.0
22	1320	120	68.2
23	1380	60	66.5
24	1440	0	65.0

Attachment 2

PERMEATION TEST RESULTS

February 2001

Diurnal Cycles (# 24 hr cycles)	Tank Label	Mfg.	Tank Volume	Treatment Level	Test Dates	Fuel Type	Avg. Loss (g/gal/day)
5	T1	Husqvarna	0.09 gal	Untreated	2/06 - 2/17	CERT Mix	1.31
5	T3	Exmark	5 gal	Untreated	2/06 - 2/19	CERT	0.55
5	T4	Murray	1.4 gal	Untreated	2/06 - 2/17	CERT	1.27
5	T5	Snapper	1.7 gal	Untreated	2/06 - 2/17	CERT	0.67
5	T7	Toro	5 gal	Untreated	2/09 - 2/19	CERT	0.77
5	T11	Coleman	5 gal	Untreated	2/16 - 2/26	CERT	0.64
5	T12	Echo	0.08 gal	Untreated	2/06 - 2/17	CERT Mix	3.42
5	T13	Shindaiwa	0.55 gal	Untreated	2/06 - 2/17	CERT Mix	2.26
5	T14	Stihl	0.38 gal	Untreated	2/06 - 2/17	CERT Mix	0.72
5	T16	Maxim	0.74 gal	Untreated	2/06 - 2/17	CERT Mix	2.46
5	T17	Honda	0.29 gal	Untreated	2/06 - 2/17	CERT	4.57
5	T25	Honda	0.12 gal	Untreated	2/06 - 2/17	CERT	4.23
Average							1.91

Attachment 2 Continued

Label	T1		
Tare	456.75	Fuel Density	2810 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	697.82	697.70	0.12	1.40
D2	697.22	697.16	0.06	0.70
D3	697.16	697.11	0.05	0.58
D4	697.11	696.99	0.12	1.40
D5	696.99	696.91	0.08	0.94
D6	696.91	696.84	0.07	0.82
D7	696.84	696.70	0.14	1.64
D8	696.70	696.57	0.13	1.52
D9	696.57	696.45	0.12	1.41
D10	696.45	696.35	0.10	1.17
			Avg.	1.31

Label	T3		
Tare	1813.4	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	13499.5	13498.9	0.60	0.14
D2	13498.9	13498.2	0.70	0.17
D3	13498.2	13496.9	1.30	0.31
D4	13496.9	13495.3	1.60	0.38
D5	13495.3	13493.6	1.70	0.41
D6	13493.1	13490.7	2.40	0.57
D7	13490.7	13488.6	2.10	0.50
D8	13488.6	13486.1	2.50	0.60
D9	13486.1	13483.9	2.20	0.53
D10	13483.9	13481.6	2.30	0.55
			Avg.	0.55

Attachment 2 Continued

Label	T4		
Tare	664.03	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	4359.74	4358.32	1.42	1.07
D2	4356.05	4354.95	1.10	0.83
D3	4354.95	4353.49	1.46	1.10
D4	4353.49	4351.89	1.60	1.21
D5	4351.89	4350.30	1.59	1.20
D6	4350.30	4348.64	1.66	1.26
D7	4348.64	4346.94	1.70	1.29
D8	4346.18	4344.45	1.73	1.31
D9	4344.45	4342.87	1.58	1.20
D10	4342.87	4341.19	1.68	1.27
			Avg.	1.27

Label	T5		
Tare	1170.56	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	5473.89	5473.34	0.55	0.36
D2	5472.14	5472.07	0.07	0.05
D3	5472.07	5471.50	0.57	0.37
D4	5471.50	5470.69	0.81	0.53
D5	5470.69	5469.97	0.72	0.47
D6	5469.97	5469.12	0.85	0.55
D7	5469.12	5468.11	1.01	0.66
D8	5467.72	5466.68	1.04	0.68
D9	5466.68	5465.62	1.06	0.69
D10	5465.62	5464.41	1.21	0.79
			Avg.	0.67

Attachment 2 Continued

Label	T7		
Tare	2129.2	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	11800.2	11799.8	0.4	0.12
D2	11799.8	11798.1	1.7	0.49
D3	11798.1	11796.8	1.3	0.38
D4	11796.8	11794.9	1.9	0.55
D5	11794.9	11792.8	2.1	0.61
D6	11792.0	11789.5	2.5	0.72
D7	11789.5	11787.0	2.5	0.72
D8	11787.0	11784.2	2.8	0.81
D9	11784.2	11781.3	2.9	0.84
D10	11781.3	11778.6	2.7	0.78
			Avg.	0.77

Label	T11		
Tare	2517.4	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	14255.6	14253.7	1.9	0.45
D2	14253.7	14251.8	1.9	0.45
D3	14251.8	14249.7	2.1	0.50
D4	14249.7	14248.0	1.7	0.40
D5	14248.0	14245.4	2.6	0.62
D6	14245.4	14242.7	2.7	0.64
D7	14241.4	14238.7	2.7	0.64
D8	14238.7	14236.1	2.6	0.62
D9	14236.1	14233.2	2.9	0.69
D10	14233.2	14230.7	2.5	0.60
			Avg.	0.64

Attachment 2 Continued

Label	T12		
Tare	147.45	Fuel Density	2810 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	356.32	356.17	0.15	2.02
D2	355.93	355.75	0.18	2.43
D3	355.75	355.58	0.17	2.29
D4	355.58	355.35	0.23	3.11
D5	355.35	355.13	0.22	2.97
D6	355.13	354.91	0.22	2.98
D7	354.91	354.66	0.25	3.39
D8	354.55	354.29	0.26	3.53
D9	354.29	354.03	0.26	3.53
D10	354.03	353.76	0.27	3.67
			Avg.	3.42

Label	T13		
Tare	548.65	Fuel Density	2810 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	1793.31	1792.84	0.47	1.06
D2	1792.06	1791.46	0.60	1.36
D3	1791.46	1790.87	0.59	1.33
D4	1790.87	1790.08	0.79	1.79
D5	1790.08	1789.31	0.77	1.74
D6	1789.31	1788.45	0.86	1.95
D7	1788.45	1787.50	0.95	2.15
D8	1787.08	1786.06	1.02	2.31
D9	1786.06	1785.03	1.03	2.34
D10	1785.03	1783.90	1.13	2.57
			Avg.	2.26

Attachment 2 Continued

Label	T14		
Tare	1174.80	Fuel Density	2810 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation		
D1	2249.71	2249.54	0.17	0.44		
D2	2248.38	2248.23	0.15	0.39		
D3	2248.23	2248.11	0.12	0.31		
D4	2248.11	2247.88	0.23	0.60		
D5	2247.88	2247.71	0.17	0.45		
D6	2247.71	2247.53	0.18	0.47		
D7	2247.53	2247.20	0.33	0.86		
D8	2247.24	2246.90	0.34	0.89		
D9	2246.90	2246.61	0.29	0.76		
D10	2246.61	2246.37	0.24	0.63		
			Avg.	0.72	Std. Dev.	0.07

Label	T16		
Tare	665.76	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation		
D1	2589.18	2587.87	1.31	1.90		
D2	2585.96	2584.62	1.34	1.95		
D3	2584.62	2583.11	1.51	2.20		
D4	2583.11	2581.52	1.59	2.31		
D5	2581.52	2579.92	1.60	2.33		
D6	2579.92	2578.30	1.62	2.36		
D7	2578.30	2576.64	1.66	2.42		
D8	2575.90	2574.20	1.70	2.48		
D9	2574.20	2572.64	1.56	2.28		
D10	2572.64	2570.77	1.87	2.74		
			Avg.	2.46	Std. Dev.	0.12

Attachment 2 Continued

Label	T17		
Tare	581.78	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	1331.78	1330.80	0.98	3.65
D2	1329.37	1328.38	0.99	3.70
D3	1328.38	1327.34	1.04	3.89
D4	1327.34	1326.12	1.22	4.57
D5	1326.12	1324.95	1.17	4.39
D6	1324.95	1323.80	1.15	4.32
D7	1323.80	1322.59	1.21	4.55
D8	1322.04	1320.80	1.24	4.68
D9	1320.80	1319.55	1.25	4.72
D10	1319.55	1318.34	1.21	4.58
			Avg.	4.57

Label	T25		
Tare	216.59	Fuel Density	2791 grams/gallon

Day	Wi grams	Wf grams	Change	Permeation
D1	564.79	564.44	0.35	2.81
D2	563.90	563.54	0.36	2.89
D3	563.54	563.12	0.42	3.38
D4	563.12	562.66	0.46	3.70
D5	562.66	562.17	0.49	3.95
D6	562.17	561.70	0.47	3.80
D7	561.70	561.18	0.52	4.21
D8	560.94	560.39	0.55	4.46
D9	560.39	559.88	0.51	4.14
D10	559.88	559.32	0.56	4.55
			Avg.	4.23